DETERMINATION OF R, LS, C AND P FACTORS IN UNIVERSAL SOIL LOSS EQUATION FOR KUANTAN RIVER BASIN

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Universal Soil Loss Equation (USLE) digunakan untuk menganggarkan purata hakisan tanah yang dijana dari Kuantan River Basin. Penggunaan USLE baru-baru ini semakin popular dalam industri untuk mendapatkan purata kehilangan tanah dan keberkesanan amalan kawalan pelan di kawasan tadahan pertanian integrasi Sistem Maklumat Geografi (GIS). Kajian ini dilakukan untuk meramalkan risiko hakisan tanah oleh kaedah USLE / GIS untuk merancang langkah pemuliharaan di tapak. Faktor erositi hujan(R), faktor topografi (LS), faktor pengurusan perlindungan (C) dan Faktor Amalan Pengurusan Hakisan (P) dikira dari data hujan, peta dan penggunaan tanah. Faktor erositi hujan dihasilkan dengan menggunakan peta erositi hujan di Guideline for Erosion and Sediment Control Malaysia dan didapati bahawa Faktor R di kawasan dekat dengan pantai lebih tinggi daripada Faktor R di kawasan dalaman Seterusnya, faktor LS dikira dengan menggunakan persamaan di mana panjang dan kecerunan diekstrak dari peta topografi. Akhir sekali, faktor C dan P setiap kawasan dijana dengan menggunakan perisian ArcGIS. Nilai-nilai C dan P diekstraksi dari kajian-kajian terdahulu dan diberikan kepada setiap poligon yang unik berdasarkan sifat-sifat pengurusan tanah dan pengurusan hakisannya. Kalau Faktor C dan P dekat dengan 1, maka kurang berkesanlah pengurusan tanah dan pengurusan hakisan dalam mengurangkan hakisan. Keputusan menunjukkan bahawa kadar hakisan tahunan berbeza antara 0.24 hingga 400.61ton/ ha/ tahun mengikut USLE.

ABSTRACT

The Universal Soil Loss Equation (USLE) model is used to estimate average soil loss generated from Kuantan River Basin. Use of the USLE has recently been extended for predicting soil loss and plan control practices in agricultural catchment by the effective integration of Geographic Information Systems (GIS) based on procedures to estimate the factor values in a grid cell basis. This study was performed to predict the soil erosion rate using the USLE/GIS methodology for planning conservation measures in the site. Rainfall erosivity (R), topographic factor (LS), cover management factor (C) and erosion management practices factor (P) values for the model were calculated from rainfall data as well as topographic and land use maps. Rainfall erosivity factor was generated by using rainfall erosivity map in Guideline for Erosion and Sediment Control Malaysia and it is found that the nearer is the location to the coast, the higher is the R factor. Next, LS factor is calculated by using an equation where the slope length and slope steepness are extracted from the topography map. Lastly, C and P factors of each sub basin are generated by using ArcGIS software. C and P values are extracted from previous studies and are assigned to each unique polygon base on their landuse and landcover properties. The closer are the C and P factors to 1, the less effective are the landcover and erosion control practices in reduce erosion. The results show that annual erosion rate for each sub basin in Kuantan River Basin varies between 0.24 to 400.61t/ha/year according to USLE.

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LIST OF SYMBOLS

e_r	Unit Kinetic Energy (MJ/ha.mm)
V_r	Total Rain Depth for Rth Interval (mm/hr)
i	Intensity (mm/hr)
E	Total Kinetic Energy
L	Slope Length Factor
λ	Sheet Flow Path Length (m or feet)
φ	72.6 foot for Imperial Units or 22.13m for SI
A	Annual Soil Erosion Rate
R	Rainfall Erosivity Factor
K	Soil Erodibility Factor
LS	Slope Length and Slope Steepness Factor
C	Cover Management Factor
P	Erosion Control Practices Factor

LIST OF ABBREVIATIONS

USLE	Universal Soil Loss Equation
WEPP	Water Erosion Prediction Program
RUSLE	Revised Universal Soil Loss Equation
MUSLE	Modified Universal Soil Loss Equation
MSMA	Manual Saliran Mesra Alam
JUPEM	Jabatan Ukuran dan Pemetaan Malaysia
LULC	Landuse and Landcover
FAO	United Nation Food and Agriculture Organisation
KRB	Kuantan River Basin
DID	Department of Irrigation and Drainage
GIS	Geographical Information System
OM	Organic Matter
LOI	Loss On Ignition
PSD	Particle Size Distribution

CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia is a country located strategically near to the equator, which provide equatorial climate with both ample sunshine and precipitation. The average rainfall Malaysia receives annually is approximately 250mm from 1901 to 2015 ("Malaysia Average Precipitation," n.d.). However, different parts of the country will receive different amount of precipitation. The highest precipitation recorded in a year is 5687mm of rainfall which took place at Sandakan, Sabah during year 2006 whereas the lowest recorded is at Tawau with precipitation volume of 1151mm recorded. With an annual average precipitation volume of 4159mm and 279 rainy days in a year, Kuching of the state of Sarawak is considered the wettest state of Malaysia, whereas Sitiawan, Perak is called the driest with annual average rainfall of only 1787 mm ("MetMalaysia: Laporan Tahunan," n.d.).

As an important component in the water cycle, rainfall happens very frequently here in Malaysia. Not only it nourishes the ground and brings life to greens, rain water continues to replenish our ground water table, which keeps the ecology system working properly. When rain water fall onto ground, the moisture undergo a process called infiltration where rainwater seeps into soil. Parts of this moisture stored in soil will replenish soil minerals and part of it will contribute to groundwater table. However, there are chances when rainfall cannot be infiltrated into soil, and surface runoff is formed. Surface runoff will wash away loose soil particles and transport them to downstreams of rivers. It is one of the major reasons that contribute to soil loss in Malaysia. Moreover due to the increasing effect of global warming, the occurrence of heavy precipitation also increased (Pour, Harun, & Shahid, 2014). Estimation of soil loss of Malaysia in the year 1995 showed an average of 7.97 tonne/hour/year and the average soil loss for the year 2003 was 6.83 t/h/year, a decline of 15 percent (Said, 2008).

Soil erosion is a process of detachment and transport of soil particles from one place to another (Michael J. Singer; Donald N. Munns, 2006; Roose, 1996). Although soil erosion is a natural phenomenon, it can bring serious problems if not managed properly. One of the most serious that can be brought by soil erosion is land degradation. Based on the report by United Nations Food and Agriculture Organization (United Nations Food and Agriculture Organization (FAO), 2008), there are approximately 1.5 million people in this world who may starve because of lack of crop yields due to land degradation. This is why prevention and control of soil erosion rate is an important topic in soil conservation issues nowadays.

1.2 Problem Statement

The negative impacts brought by soil erosion rate can be divided into two categories, on-site effects and off site effects. Loss of soil is one of the on-site effects, where kinetic energy caused by rainfall will create a splatter effect on the ground, removing the soil particles on the surface layer of ground. This will cause over-exposure of roots of plants. Other than that, there are some non-renewable minerals in soil and soil nutrients that might be washed away by surface runoff (Guo, Liu, Xie, Liu, & Yin, 2015). Consequently, these will result in reduced yields of crops.

On the other hand, soil erosion can bring some off-site effects too, including pollution of waterbodies downstream, disruption of the ecosystem and disappearing water table. After detaching loose soil particles from ground, loosened soil particles will float in this moving stormwater and be transported by surface runoff to downstream areas. Consequently, this will adversely affect the water quality. Also, since these soil particles are opaque and will not dissolve in water, it will block the vision of aquatic organisms. Other than that, these particles might restrain plants respiration as they are floating in the water and might be inhaled into the organism. As time pass, loosened soil particles in the water will slowly settle down and become sediment. As a result, the water depth will decrease.

In this era, land degradation is a major issue all over the world as the rate of soil formation is a lot slower than the rate of soil erosion, especially with disturbance from human activities like deforestation and construction (Addis & Klik, 2015). There are a few methods developed to determine soil loss rate, namely the WEPP, RUSLE, MUSLE and USLE. Using the USLE model, the annual soil loss rate can be calculated based on a few parameters, which are rainfall erosivity, soil erodibility, slope length and slope steepness, crop management applied and lastly the practice and erosion control applied. There are many soil loss assessment conducted in different parts of Malaysia by utilising USLE (Khosrokhani & Pradhan, 2014; Mir, Gasim, Rahim, & Toriman, 2010a; Rizeei, Saharkhiz, Pradhan, & Ahmad, 2016) and the results varies spatially with different soil properties, human activities and slope. By

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